Hawkes processes for market order arrivals on the German intraday power market and their application in optimal market maker pricing

Strommarkttreffen Juni 2019

Graf von Luckner, Kiesel | Chair for Energy Trading and Finance | University of Duisburg-Essen

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- ▶ We consider a market maker (MM) operating on the intraday market for power deliveries in Germany.
- ▶ We study the problem of how she can optimally price her buy and sell limit orders (LO).
- ▶ Dependence on her current inventory as well as market characteristics and state, e.g.
  - ▶ Self-excitement in market order (MO) arrivals, ...
  - ▶ Bid-ask spreads well above tick size

Value function

We consider the following value function for the MM:

$$V(t, X, q, S, H, \boldsymbol{\lambda}) =$$

$$\sup_{(\delta_{SL}(u), \delta_{BL}(u))_{t \leq u \leq T} \in \mathcal{A}} \mathrm{E}\left[X(T) + q(T)\left(S(T) - \mathrm{sign}\left(q(T)\right) H(T) - \alpha q(T)\right) - \phi \int_t^T q(u)^2 \, du \,\bigg|\, \mathcal{F}(t) \right], \tag{1}$$

where

$$\mathrm{sign}(q(t)) := \begin{cases} 1 & \text{if } q(t) > 0 \\ 0 & \text{if } q(t) = 0 \\ -1 & \text{if } q(t) < 0. \end{cases}$$

and $\mathcal{A}$ is the set of admissible controls.
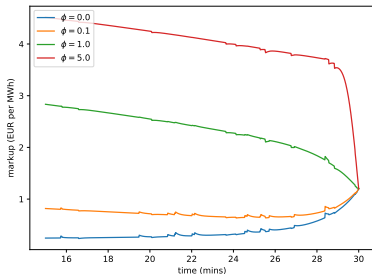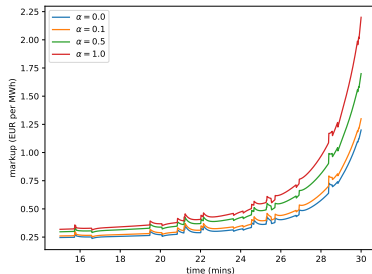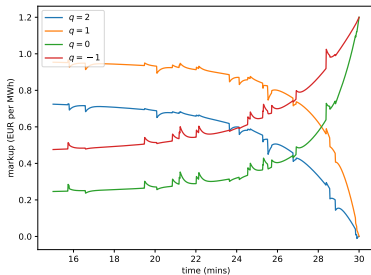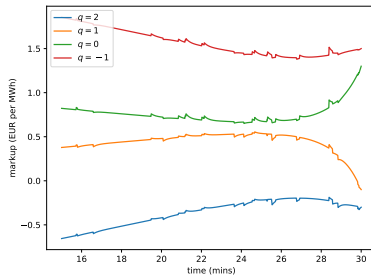
Different ϕ, α

(a) $\alpha = 0$.

(b) $\phi = 0$.

Figure: Optimal markup over time for different running and terminal inventory penalties. $q = 0$ MWh, $h = 0.5$ EUR per MWh.

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Different q, ϕ

(a) $\alpha = \phi = 0$.

(b) $\alpha = \phi = 0.1$.

Figure: Optimal markup over time for different inventory levels and inventory penalties.
$h = 0.5$ EUR per MWh.

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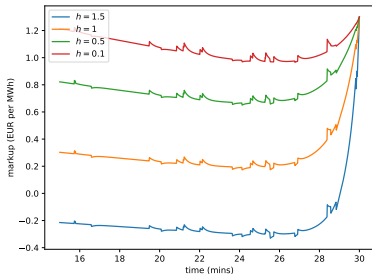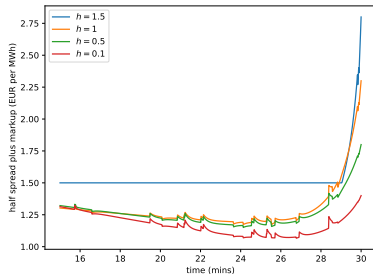E S S E N**

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Different h

(a) δ_{SL}^*.

(b) $h + \delta_{SL}^*$.

Figure: Optimal markup and half spread plus optimal markup over time for different half spreads. $q = 0$ MWh, $\phi = \alpha = 0.1$.
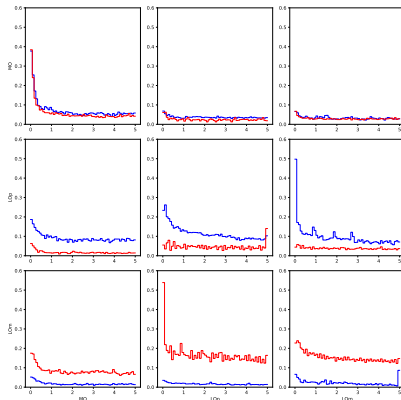
Arrivals

Figure: Blue: average number of sell MOs (first row), buy LOs placed into the bid-ask spread (second row) and buy LOs canceled from the first level of the order book (third row) in bins of 5 seconds over 5 minutes after the arrival of a sell MO (first column), a buy LO being placed into the bid-ask spread (second column) and a buy LO being canceled from the first level of the order book (third column).

Test design

- ► Contracts with delivery in peak hours of 05/2015 and 06/2015 are considered.
- ► 2 hours of trading ending 5 mins before gate closure.
- ► Point process param. are estimated for each peak hour with data from 04/2015 and averaged b/w buy/sell side.
- ► Expected impacts are estimated for all peak hours with data from 04/2015 and averaged b/w buy/sell side.
- ► Fill probability param. are estimated for all peak hours with data from 04/2015 and averaged b/w buy/sell side.
- ► One unit of inventory is 0.1 MW.
- ► We assume that if the worst price executed by a MO is the same or worse than the price of the MM's LO on the relevant market side, the MM's LO is executed.
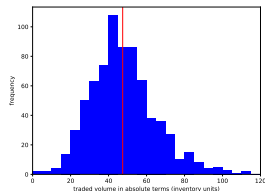
Result example
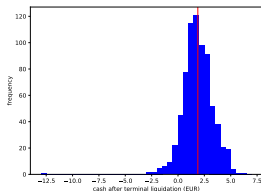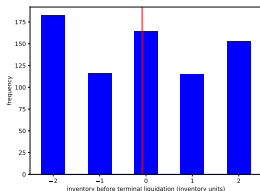
(a) PnL.   (b) Inventory.   (c) Volume.

Figure: Distributions resulting from backtesting the strategy. $\phi = 1, \alpha = 0$.

PnL (EUR)	Inventory (MWh)	Volume (MWh)
1.273	-0.004	7.190

(a) Naive.

$\phi \setminus \alpha$	PnL (EUR)			Inventory (MWh)			Volume (MWh)		
	0e+00	1e−01	1e+00	0e+00	1e−01	1e+00	0e+00	1e−01	1e+00
0e+00	1.814	1.815	1.815	-0.006	-0.006	-0.006	5.176	5.176	5.174
1e+00	1.825	1.826	1.825	-0.007	-0.007	-0.007	5.057	5.057	5.057
1e+01	1.877	1.877	1.877	-0.005	-0.005	-0.005	4.541	4.541	4.542

(b) NHPP.

$\phi \setminus \alpha$	PnL (EUR)			Inventory (MWh)			Volume (MWh)		
	0e+00	1e−01	1e+00	0e+00	1e−01	1e+00	0e+00	1e−01	1e+00
0e+00	1.876	1.876	1.878	-0.009	-0.009	-0.009	4.810	4.811	4.811
1e+00	1.880	1.881	1.881	-0.008	-0.009	-0.009	4.743	4.743	4.744
1e+01	1.879	1.879	1.878	-0.007	-0.007	-0.006	4.364	4.364	4.364

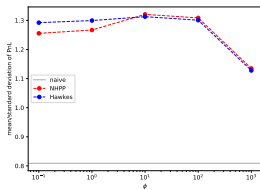(c) Hawkes.

Table: Mean of PnL, inventory and traded volume at the end of trading.
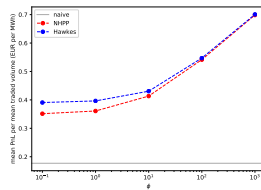
Performance indicators
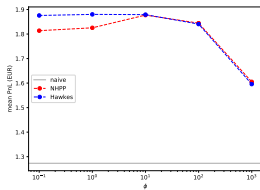
(a) PnL.   (b) Sharpe ratio.   (c) PnL per traded volume.

Figure: Performance indicators as a function of ϕ for model with excitement (blue) and without (red). $\alpha = 0$.

- ϕ has a substantial impact on markups/downs.
- Optimal markups/downs vary substantially with current half spread.
- Excitement may be observed empirically in events which (potentially) have an impact on mid price and half spread.
- Backtest: Mean PnL is positive. Including Hawkes increases mean PnL and decreases mean traded volume.